

Solar Eclipse Expedition to Kalaa-es-Senam, Tunis.

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When the Court of the University of Glasgow made to me an unsolicited grant of £50 to see the eclipse, I decided to take active part in its observation, though in a small way. Together with Mr. Franklin-Adams I accepted the invitation of Mr. Andrew Crookston, Glasgow, to observe it at his mines at Kalaa-es-Senam, Tunis. The station lies 33 m. 30 s. east of Greenwich (from map) at a latitude of $35^{\circ} 45' 19''$ as determined from pole-star observations. Its altitude above sea-level is 953 metres. It is about 40 miles from Morsott, a station on the railway from Bona to Tebessa.

I set myself the problem to determine from a series of correctly-timed photographs the law according to which the light of the corona decreases with the distance from the sun. I designed mechanisms by which 10 exposures are automatically made on one plate, the mechanisms being governed electrically by a pendulum clock. I employed two cameras, one with a Cooke triple achromatic lens of $3\frac{1}{2}$ inches aperture and 60 inches focal length, which belongs to the Glasgow spectrograph, the other with a Ross portrait lens of 2 inches aperture and 12 inches focal length. They were fed by a cœlostat of 8 inches aperture, which had been kindly lent to me by the Royal Dublin Society. In front of the two object-glasses a rotating shutter was mounted which served both cameras. The rotating shutter has four oblong apertures, 90° apart; it is rotated by clockwork driven by a spring, and its motion is governed by the armature of an electromagnet. When the armature is attracted the shutter rotates through 45° , bringing an opening opposite the object-glasses, and when it is released it turns again 45° , when the shutter shuts off the light. The contacts are made by a pendulum clock, and they are so devised that make or break can occur only when the pendulum is at or near its position of rest. I arranged for five exposures of 1 second duration, and five exposures lasting respectively 3, 9, 20, 46, and 89 seconds. Their actual durations are 0.86, 0.82, 0.80, 0.82, 0.87, 2.82, 9.02, 20.84, 45.91, and 89.04 seconds, as determined automatically on the chronograph. At the first four exposures of 1 second, different screens, each with 13 holes, are in front of the object-glasses. At the first exposure the screen leaves about one-sixteenth of the object-

glasses free, at the second one-eighth, at the third one-fourth, and at the fourth one-half. These screens are geared to the clockwork which rotates the shutter.

The plate-holder of the Cooke camera is 17×3 inches, it slides lengthways inside a metal box 32×4 inches. It is moved by rack and pinion, the rack being attached to the plate-holder and the bearings of the axis of the pinion being fixed to the box. Spring-driven clockwork communicates its motion by means of a shaft to the pinion. The clockwork is governed by the armature of an electro-magnet; when the armature is attracted the plate-holder moves 1 inch onwards, and when it is released it moves another inch. The necessary contacts are made by the pendulum clock. The same mechanism actuates on the plate-holder of the small camera, only the steps are correspondingly smaller. I arranged the contacts in such a way that for the first four exposures the plate moved one step onwards, for all the others two steps, and when the plate had been slid along I allowed 2 seconds for the camera to settle before the next exposure was made. Of the 206 seconds for which I made provision, 173 seconds are occupied by the exposures, 15 seconds are taken up by changing of plates, and 18 seconds are lost. Owing to reasons which I need not explain here, I did not unpack the boxes until August 26. Unfortunately, I found the automatic apparatus damaged, though it had been carefully packed, but not sufficiently for a journey on a road like that from Morsott to Kalaa. I repaired the damage as well as I could on the 27th, and adjusted the cœlostat on the 28th. On the 29th a southern gale made all observations impossible, and, in fact, all apparatus except the cœlostat had to be dismounted and taken indoors. On the morning of the eclipse they were re-erected and tried, not, however, with the plate-holders, because I was afraid that the plates, which had been placed inside the plate-holders, would be spoiled by the heat. When the signal of the beginning of totality was given, I set the pendulum in motion, and all went right until the fifth exposure (1 second) was finished, then the plates advanced only one step instead of two, and the same took place after the next exposure (9 seconds); between the seventh exposure, of 3 seconds, and the eighth exposure, of 89 seconds, the propelling mechanism failed to move the plates. Before the last two exposures, of 21 seconds and 46 seconds, the plates were moved on their proper amount. In consequence, the two exposures of 89 seconds and 3 seconds are superposed, giving one of 92 seconds, and the images belonging to the fifth, sixth, and seventh exposures are at half the distance from one another that I had meant them to be. The irregularity was caused by friction of some damaged parts of the mechanisms. I developed the plates the same night, the two plates of the

Cooke camera, which are cut from the same full plate, and the small plate of the Ross camera being put in the same developing tray for seven minutes. The result is very satisfactory. Each camera has furnished nine pictures of the corona instead of the ten arranged for. Eight photos by the Cooke camera are fine from the pictorial point of view, especially the five of 1 second exposure and that of 21 seconds. The focus appears to be correct, and the cœlostat has performed excellently. For the 92 seconds exposure the photographic plate was too small. It will be difficult to reproduce the negatives on one plate on account of the densities of the background of the various negatives, which increase with the exposure. There is direct evidence that the light which illuminated the field came from the cœlostat mirror, and though the sky was unexpectedly bright, I think it must be attributed to coronal light diffusely reflected by the large whitish dust particles which were always settling on the mirror. I might have suppressed this background by judicious developing had it not been my aim to introduce nothing that I could not exactly reproduce at home. The long-exposure photographs obtained with the Ross portrait camera are over-exposed, that of 90 seconds to such an extent that the corona close to the moon's limb and the protuberances are reversed. Since my return home I have measured the plates and reduced the measurements. Experiments will be undertaken without delay from which I can derive the relation which connects time of exposure and intensity of radiation for the same degree of blackness on the photographic film. I shall employ the same photographic plates and develop them in the same way as the eclipse photographs.